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APPLE THINNING INVESTIGATIONS

1920 to 1935

R. C. PALMER
SUPERINTENDENT

D. V. FISHER
GRADUATE ASSISTANT

DOMINION EXPERIMENTAL STATION,
SUMMERLAND, B.C.

EXPERIMENTAL FARMS BRANCH

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Harvesting the crop from a heavily thinned McIntosh apple tree at the Summerland Experimental Station; 1936 crop 2,010 pounds.

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INTRODUCTION

Thinning, or the removal of a portion of the crop with the object of improving the fruit permitted to remain on the tree, is an orchard operation which calls for the exercise of sound judgment. In order that the grower's judgment be sound, it must be based on accurate evidence. Much evidence of value can be accumulated by the grower in his own orchard; in fact, it will always be necessary for him to modify his practice to conform with local conditions. Few growers, however, have the time or inclination to carry on detailed thinning experiments over a period of years. The natural tendency is for the grower to adopt over his whole orchard that practice which, after the first season's work, seems to promise greatest financial returns. It is only at an experimental institution, where experimental work is given first place and financial returns are considered of secondary importance, that it is possible to conduct a systematic series of thinning experiments over a long period of time. With these facts in mind, an apple orchard planted at this station in 1916 was laid out to serve as an extensive test of various thinning practices. As the trees have been producing commercial crops for 16 years, it is now possible to present detailed results which, it is hoped, may prove of interest and value to a large number of growers, as well as to scientific investigators.

REVIEW OF LITERATURE

A review of the literature on apple thinning investigations reveals certain well established facts and also some conflicting evidence which it may be well to present as an introduction to this report. The effects of thinning the apple crop as reported in published experiments may be conveniently reviewed under the following headings: yield, size, colour, blemishes, quality, bearing habit, and tree growth.

Influence of Thinning on Yield of Apples

In experiments conducted with the Baldwin variety, Ellenwood (18)* found that total yield was not reduced by thinning. Rollins (42) working with the same variety noted a decrease in yield as a result of thinning. Magness and his co-workers (35) state that thinning had a definite tendency to reduce the yield of fruit. Fletcher (22) working with York Imperial and Jonathan found that where spacing exceeded 10 and 6 inches apart per apple respectively, yield was reduced. This spacing corresponded to 37 leaves per fruit for York Imperial and 41 leaves per fruit for Jonathan. Howlett (33) reported that with Duchess apples thinned to one fruit to a cluster before the June drop, the thinned trees produced a greater total tonnage than the unthinned trees. McCormick (37) reported that blossom thinning of biennial bearing Newtowns and Ortleys in the heavy bearing year followed by regular thinning six weeks later, resulted in as large a crop in the "off" year as in previous "on" years. Collins (15) working with seven varieties in Nova Scotia found that the reduction in yield due to thinning was very slight and was greatly outweighed by increase in returns.

* Numbers in parentheses refer to the reference list at the end of this bulletin.

Influence of Thinning on Size of Apples

The most generally recognized advantage of thinning is the increase in size of fruit produced. With 21-year-old Ben Davis trees, Auchter (5) showed that thinning increased the size of the fruit to such an extent that the amount of marketable fruit was doubled. In another experiment, Auchter (4) found that thinning materially increased the size and amount of fruit produced by 11-year-old Stayman trees. In still another experiment, Auchter (3) noted that in all cases where the trees had a good crop, thinning increased the size of the fruit. In some plots an extra large grade was secured, while in others a considerable amount of fruit was made saleable which otherwise would not have been so. Ellenwood (18) found that the size of Baldwin apples was greatly improved by thinning. Rollins (42) working with the same variety, noted a slight increase in size of fruit. Aldrich (1), Batchelor (8), Collins (15), Fletcher (22) and Brown (10) all report that thinning increased size. Work conducted by Haller and Magness (25) with ringed branches showed that 40, 50 and 75 leaves per apple respectively should be available for sizing up the fruit of Grimes Golden, Ben Davis and Delicious. Magness *et al.* (35) found that with ringed branches of Delicious, Jonathan, Rome Beauty and Winesap, size of fruit for any given number of leaves showed high positive correlation with the size of the leaves. However, with increased foliage, they found that the relative gain in size of fruit was correspondingly less, leaf surfaces exceeding 30 leaves per apple failing to increase the size of the fruit. While 20 to 30 leaves per fruit were required to produce apples of normal size on ringed branches, the above investigators estimated that 40 to 50 leaves per fruit would be required to produce fruit of similar size under orchard conditions. Pickett (40) working with Delicious, Jonathan, Winesap and York Imperial, obtained the largest fruits with 50, 30, 40 and 40 to 50 leaves respectively per apple. Cummings *et al.* (17) found that the number of leaves on different trees varied greatly, but with respect to their size and surface areas, close association existed between larger leaves and larger apples. Fisher (21) reported a positive correlation between leaf area and fruit size. Recent work by Haller (26) showed that fruit may utilize plant food which is synthesized at considerable distances from where the apple is growing. The movement was found to take place either upward or downward and from one small branch to another in the direction of the fruit. However, he found that while fruit could draw successfully upon food manufactured 6 to 8 feet away, it could not compete upon equal advantage with fruit growing adjacent to the food supply.

Influence of Thinning on Colour of Apples

According to Murneek (38) thinning is the most certain and most effective means of obtaining a crop of well coloured apples. The work of Beach (9), Auchter (3, 4, 5), Fletcher (22) and Rollins (42) indicates that when the crop is heavy, thinning improves the colour of the fruit. Chandler (13) notes that with trees bearing only a moderate crop there appears to be a greater brightness due to healthy development as well as to an increased amount of red over the surface. He concludes that "it is probable that the benefit to colour produced by thinning is greater than would be produced merely by the increased amount of light reaching parts of the surface." That thinning has a physiological as well as mechanical effect on colour was demonstrated by Haller (26) who found that colour increased with leaf area, and by Roberts (41) who reported that the colour of the fruit varied inversely with the nitrogen content.

Influence of Thinning on Blemishes on Apples

A large number of injuries on apples are caused by insects and diseases. Most of these injuries may be prevented by proper and timely spraying. As the

crop develops, however, trees loaded with fruit cannot be sprayed properly because heavily laden branches often cover other branches so completely that many specimens on the inside remain practically unsprayed. Attention has been drawn to the above facts by Murneek (38). It has also been pointed out by Brown (10) that where fruit hangs in clusters, thinning to one fruit to a spur permits more effective spraying.

Influence of Thinning on Quality of Apples

Quality, which may be defined as the sum total of all those factors which give desirability to a product, includes in the case of the apple not only size and colour, but also flavour. Magness *et al.* (35) found that fruit with a large leaf surface was higher in total sugars. They also found that with the exception of Delicious, total titratable acid increased with an increasing leaf surface per apple. Haller and Magness (25) working with Grimes Golden, Ben Davis and Delicious, found that an abundant leaf area increased the percentage of sugars, acid and dry weight of apples. Haller (26) found that fruit grown with a small number of leaves was of very poor quality, this being especially true of Delicious and least true of Jonathan. On the other hand, Fletcher (22) found that Jonathan with increased leaf surface per apple, gave increased quality of the resulting fruit.

Influence of Thinning on Bearing Habit of Apple Trees

One of the most important questions associated with fruit thinning practice is whether or not thinning during one season or over a period of years will reduce the tendency of certain varieties to bear alternately. Auchter (5) found that thinning did not affect the alternation of bearing in either old or young trees or trees of different varieties. This is substantially in accord with the work of Beach (9) and Gourley (23). Wiggins (43) found that with Gano, Rome Beauty and Jonathan, 8·2, 8·5 and 15·8% respectively of the spurs that fruited in the previous year bloomed in the succeeding year. Auchter (5) showed that although many spurs bloom in successive years it is very seldom that a spur fruits one year and blooms the next.

Crow (16), Auchter (5) and Auchter and Schrader (6) demonstrated that when thininng was done at blossoming time, many of the spurs bloomed again the following year. Aldrich (1) reported that the thinning of vigorous trees if sufficiently heavy usually resulted in increased blossom bud formation even if the thinning were done as late as July 1. Bailey (7) removed the blossoms from 50, 75 and 100% of the spurs on biennial bearing Wealthy, Duchess and Transparent trees, with the result that formation of blossom buds occurred after the 100% removal but not in the case of the 50 and 75% removals. McCormick (37) found that blossom thinning of Newtowns and Ortleys in the heavy bearing year and in successive years completely restored such trees to heavy annual bearing. It should be noted, however, that in McCormick's experiments, the blossom thinning was followed six weeks later by regular thinning. Magness *et al.* (36) worked out the number of days elapsing after full bloom during which thinning would result in at least 25% set of fruit spurs for the following year. Their results varied widely according to variety, tree vigour and district, extending from 54 to 90 days after full bloom for a 25% set of spurs, and from 61 to 105 days for the effect of thinning upon fruit bud formation to be entirely lost. Aldrich *et al.* (2) showed that fruit bud formation was a function of leaf area per fruit and reported that in vigorous trees heavy thinning within six weeks of the blossoming date was apparently effective in increasing fruit bud formation for the following year. Work done by Harley *et al.* (27, 28) in Washington with biennial bearing Newtowns has shown that where heavy thinning was done not later than 40 days after full bloom, a good

crop of terminal and spur buds was formed for the next year. Thinning to 70 leaves per apple resulted in a set of 47% of the spurs and thinning to 50 leaves resulted in a set of 23%. Brown (11) of Oregon found that thinning biennial bearing Newtowns when the fruit was one-half inch in diameter to 12 inches apart, or thinning alternate sectors of the tree to 5 inches and removing all the fruit from the other sectors, resulted in the set of approximately 25% of the spurs, whereas commercially light thinned trees set fruit buds on only 1·6% of spurs. Auchter (3) showed that complete removal of the fruit from the entire tree or from half a tree resulted in blossom bud differentiation and successive blooming.

Aldrich (1) found that in nearly all cases where trees blossomed the year following thinning, the thinned trees had an increased carbohydrate accumulation three to eight weeks after thinning the previous summer. Ellenwood (19) showed that with Jonathan and Grimes Golden in the " off " year, the crop tended to increase in proportion to the " on " year thinning. Chemical analysis of spurs at the time of bud differentiation by various investigators, Hooker (30), Harvey and Murneek (29) and Auchter and Schrader (6) have shown that fruit bud formation is associated with a relatively high carbohydrate-nitrogen ratio. Magness *et al.* (35) reported that fruit bud formation is associated with an abundance of synthesized materials in the leaves. Roberts (41) reported that both spur and terminal bud formation appear to be particularly related to secondary thickening, buds forming where marked thickening occurs.

Gourley (24) states that " as a rule the sooner the thinning is done after the June drop, the better will be the result, since by so doing the developing seeds are prevented from draining the energy of the tree." Howlett (32) reports that the competition for food materials among the partially developed fruits is the most important factor causing the June drop. With Grimes Golden he states that the greater the number of fruits to a cluster, the greater will be the amount of the June drop. In another publication, Howlett (33) reports that Duchess apples thinned one to a cluster before the June drop, dropped from 16 to 52% of their fruits.

Influence of Thinning on Apple Tree Growth

According to Magness (35) and Haller (26), with a normal crop approximately half of the dry matter produced annually by the tree goes into production of the fruit and half into wood formation. With a heavy crop, twig and trunk diameters are thus greatly reduced. Pickering (39) stated that fruiting greatly reduced the growth of trees, and Auchter (3) found that excessively heavy crops were injurious to young trees causing weak growth and bent branches. Chandler (12) found that the total leaf surface was smaller in heavy bearing years and the increase in trunk diameter was greatly reduced. In another publication (14) he noted that fruiting reduced the growth of Oldenburg trees. Murneek (38) states that the usual consequences of over-bearing are reduced vegetative growth, smaller roots and reduced fruit bud formation. On the other hand, Mack (34) and Roberts (41) found that terminal growth was relatively greater in biennial varieties in the " on " than in the " off " year. Hooker and Bradford (3) reported that the diameter increase of the branch was less in the fruiting than in the non-fruiting year. Aldrich (1) found that heavy thinning showed pronounced effects upon the vigour of trees, more especially where irrigation was not practised. Chandler (13) states that "since thinning is done so late that the terminal buds have generally formed, it cannot influence top growth in the same year unless it be for the thickening of the trunk and large branches."

DEGREE OF THINNING EXPERIMENTS

A review of the literature on thinning of apples indicates that there is a good deal of information available on this subject. Nevertheless, there is need of further experimental evidence, especially concerning the effects of different degrees of thinning practised consistently over a period of years. It was to secure such information that this project was undertaken.

MATERIALS AND METHODS

The orchard used for degree of thinning experiments slopes gently from west to east. The soil is sandy loam underlaid with gravel. Special attention has been paid to building up this soil by the use of leguminous cover crops, and care has been taken to secure adequate and uniform distribution of irrigation water. The orchard has been systematically pruned and sprayed each year. These general orchard practices have resulted in healthy, vigorous trees which exceed average growth dimensions for their age.

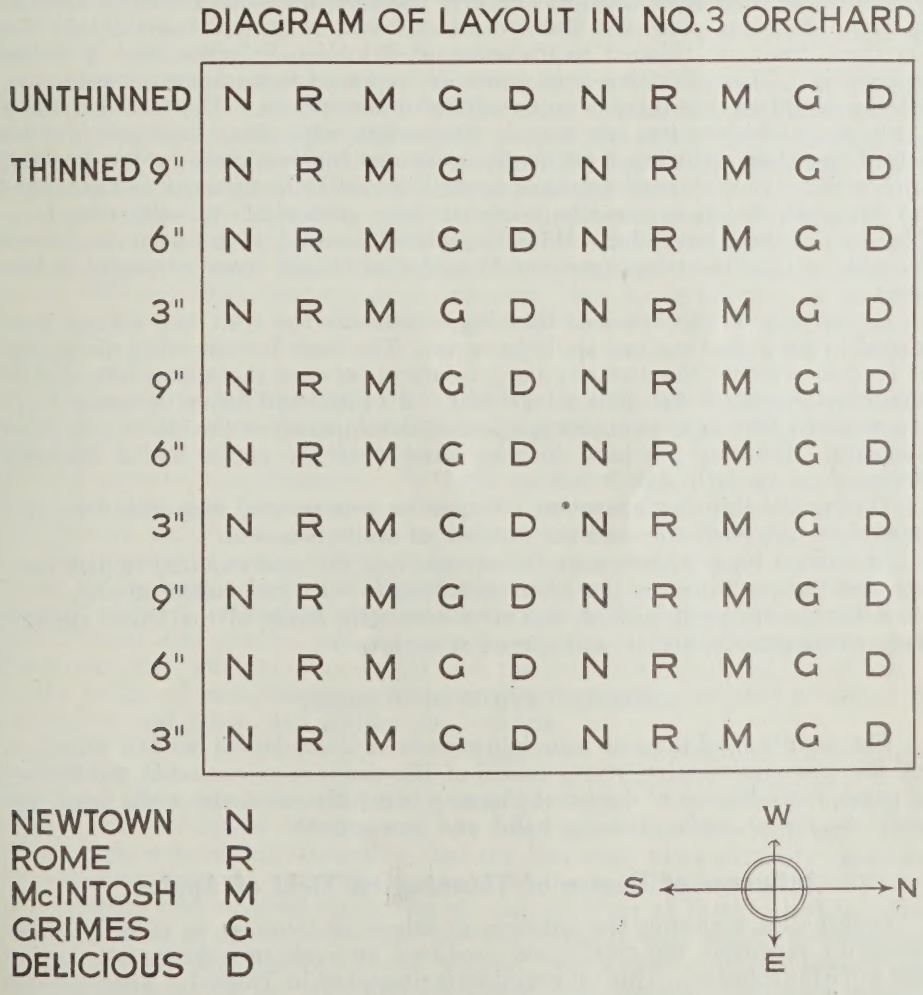


FIGURE 1

The trees employed in the degree of thinning experiment were planted in 1916. The distribution of the trees and of the thinning treatments is shown diagramatically in Figure 1. It will be noted that there were originally two rows of each of the five varieties Newtown, Rome Beauty, McIntosh, Grimes Golden and Delicious. Unfortunately, several of the Grimes Golden trees developed collar rot. In order to provide uniform conditions of light and spacing for the remaining varieties, it was decided to remove all the Grimes Golden in 1933. Accordingly, the results from the Grimes Golden variety are not included in this report.

Irrigation water was applied from the west end of the orchard with the result that each heavily thinned tree is closer to the source of irrigation water than is the medium thinned tree adjacent to it. Each medium thinned tree is in turn closer to the water supply than is the lightly thinned tree adjacent to it. It is therefore possible that the performance of the differently thinned trees may have been slightly influenced by their location in relation to the water supply.

Thinning treatments applied have been systematically distributed over the orchard so as to overcome as far as possible any errors due to soil variability. Ever since the trees came into bearing they have been thinned regularly according to the following plan: the first tree in each row is an unthinned check; the next three trees are thinned to distances of 9 inches, 6 inches, and 3 inches respectively. These thinning treatments are repeated twice again in each row, with the exception that there is no repetition of check trees. The fact that there is only one unthinned tree per row, in comparison with three trees per row for each of the three thinning treatments, is an obvious weakness in the lay-out. Furthermore, the unthinned trees are located immediately adjacent to the irrigation flume which has apparently rendered them susceptible to collar rot from which two of them have died. With these facts in mind, it has been considered advisable to omit the results secured from the unthinned trees in preparing this report.

In carrying out the various thinning treatments the fruit has always been reduced to not more than one apple per spur. The basis for removing the apples has been to estimate the distance along a lateral between the apples intended to remain and eliminate the intervening fruits. All small and defective apples have been removed first so as to encourage perfect development of the fruits permitted to remain. Thinning has been done by hand when the apples had a diameter between $\frac{3}{4}$ of an inch and 2 inches.

During the thinning operation information was secured regarding the time required to thin each tree and the number of fruits removed.

At harvest time, records were taken regarding the time required to pick each tree, and the character of the crop according to size and colour grades.

After the crop was picked, measurements were made of the trunk circumference, twig growth, height, and spread of each tree.

PRESENTATION OF RESULTS

The results of degree of thinning experiments conducted on the Summerland Experimental Station over a period of 16 years are presented in the following pages, the influence of degree of thinning being discussed under the headings: yield, size, colour, value, bearing habit and tree growth.

Influence of Degree of Thinning on Yield of Apples

Information regarding the influence of degree of thinning on yield has been secured by recording the total yield produced by each tree during the period 1920 to 1935 inclusive. This information is presented in Table 1. The probable errors (calculated by Bessel's formula) are included for each yield figure to indi-

cate the degree of variability in each set of trees. It will be noted that these errors tend to be high. This is probably explained by the relatively small number of trees in each plot.

TABLE 1.—INFLUENCE OF DEGREE OF THINNING ON YIELD OF APPLES. TOTAL YIELD PER TREE IN POUNDS, 1920–35

Variety	Yield in pounds per tree		
	Thinned 9 inches	Thinned 6 inches	Thinned 3 inches
	lb.	lb.	lb.
McIntosh	6,126±332	6,016±235	5,976±237
Delicious	5,845±434	5,823±301	5,614±367
Rome Beauty	4,503±123	4,275±419	4,152±387
Newtown	2,991±224	3,056±251	3,366±221

It is evident that with all four varieties studied, the distance to which the apples were thinned has not resulted in any significant difference in total yield produced during the 16-year period. Those small differences which do exist are obviously within the range of experimental error.

Another interesting comparison apparent in the data presented in Table 1 is the relative yielding ability of the four varieties. McIntosh and Delicious have given highest yields, approximately 6,000 pounds per tree. Rome Beauty has given an intermediate yield of approximately 4,300 pounds per tree, and Yellow Newtown the lowest yield of about 3,000 pounds per tree.

It was felt that interesting information could be secured by comparing the number of apples removed at thinning time with the total number of fruits carried by each tree. These data have been compiled from results recorded during 1932 and 1933, the average of two years' data being taken so as to allow for alternation of bearing. The averages presented were secured in each case from six heavily thinned and an equal number of medium and lightly thinned trees of each variety.

The procedure followed when thinning was to pick the fruits into pails and record the weight of each pailful before dumping the thinnings. Separate records were kept for each tree, and the average numbers of apples per pound from four 1-pound samples were obtained. By knowing the weight of thinnings removed from each tree and the number of apples obtained in a pound of fruit, the approximate number of apples thinned from each tree was readily calculated.

The number of apples picked at harvest was not quite so easy to determine. Owing to the large numbers of fruits involved, the individual apples were not actually counted. However, the mature fruit from each tree was graded into four different size grades, and the number of pounds of each grade recorded. The approximate number of apples for each tree was then calculated, by multiplying the weight of each size grade harvested by the average number of apples in a pound of that grade, and adding the products.

Table 2 gives a summary of the results that were obtained. From data presented in the third column, it will be noted that degree of thinning had no significant effect upon the amount of crop produced. The data in column 4 indicate that the lighter the thinning, the fewer were the fruits removed. It is interesting to note in this connection, that the June drop was sufficiently extensive in the case of Newtown and Delicious to space the fruit in such a way that very little thinning was required on the lightly thinned trees of these varieties. The average number of apples picked per tree was found to vary slightly between the heavily, medium and lightly thinned trees of each variety. Approximately 20 per cent more apples per tree were harvested from lightly than from heavily thinned trees of each variety.

TABLE 2.—RELATION BETWEEN NUMBER OF APPLES THINNED AND NUMBER OF APPLES PICKED

Averages for years 1932 and 1933

Variety	Thinning distance	Average yield per tree per year	No. of apples removed at thinning	No. of apples picked	Total No. of apples per tree	Percentage of apples removed by thinning
	in.	lb.				%
McIntosh	9	667	2,059	1,728	3,787	54
	6	627	1,626	1,913	3,539	46
	3	665	979	2,096	3,075	32
Delicious	9	748	1,609	2,173	3,782	42
	6	763	994	2,244	3,238	31
	3	700	260	2,347	2,607	10
Rome Beauty	9	599	2,083	1,502	3,585	58
	6	620	1,739	1,926	3,665	47
	3	586	1,221	1,968	3,189	38
Newtown	9	360	1,799	1,333	3,132	57
	6	386	808	1,508	2,316	35
	3	385	370	1,817	2,187	17

The percentages of apples removed in thinning are of special interest, in that they indicate the bearing habit of the different varieties. Rome Beauty, which set its fruit in clusters spaced well apart from each other, showed comparatively small differences in the percentages of fruits removed from differently thinned trees. This is because 6- and 3-inch spacing was sometimes impossible with this variety, owing to the fact that the fruits were located in clusters spaced approximately 9 inches apart. Delicious required the least thinning of any variety in this experiment, because it tended to thin itself naturally in the June drop.

An interesting point which arises in connection with this experiment is the fact that the total number of apples set per tree by the lightly thinned trees was in every case smaller than that set by medium thinned trees, and these in turn set a smaller number of apples than heavily thinned trees. While this may to some extent be attributed to the smaller size of the lightly thinned trees, the explanation probably lies in the cumulative effect of thinning repeated year after year on the same trees. Increased food reserves stored in heavily and medium thinned trees may well encourage greater tree growth as well as more fruit bud formation and increased set of fruit. These results suggest that in contrast with light thinning, heavy thinning practised consistently over a period of years has resulted in an increased set, and consequent increase in the amount of fruit removal necessary at thinning time.

Influence of Degree of Thinning on Size of Apples

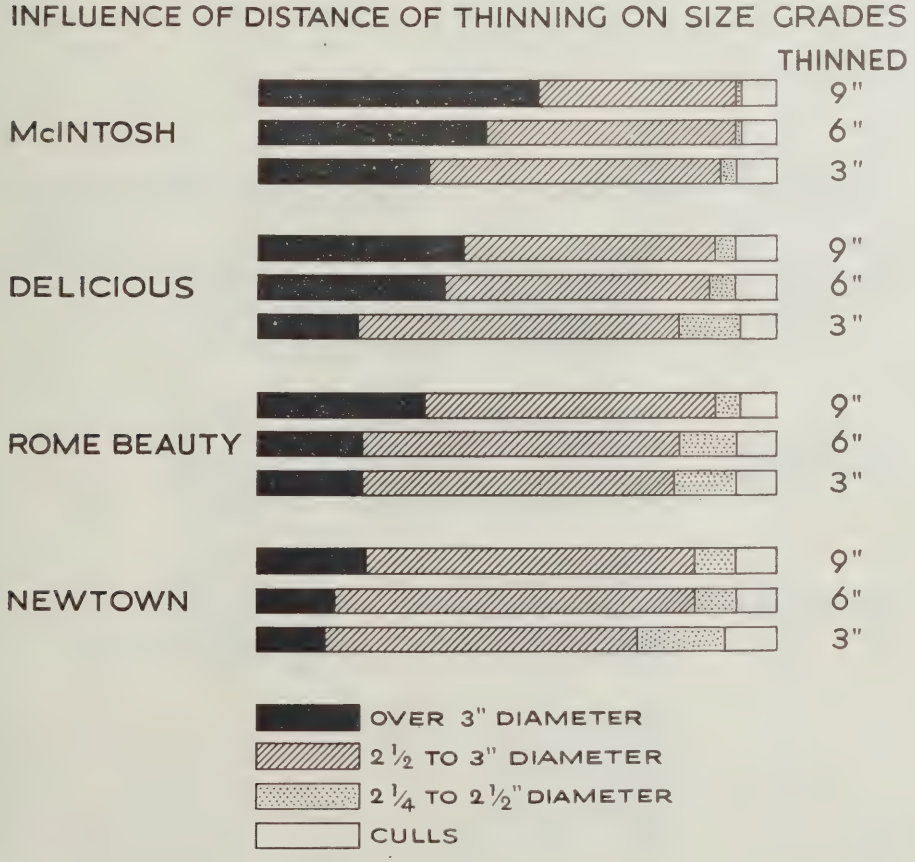
Each year since the experimental orchard came into bearing, the apples have been carefully graded into three size grades, namely, over 3 inches, $2\frac{1}{2}$ to 3 inches, and $2\frac{1}{4}$ to $2\frac{1}{2}$ inches in diameter. These size gradings correspond roughly to the commercial ratings "large," "medium" and "small" for the varieties under investigation. Apples under $2\frac{1}{4}$ inches in diameter, windfalls and fruits affected by limb-rub or other deformity have been classified as culls. Table 3 and Figure 2 show the results of size grading carried out during the 6-year period 1930 to 1935 inclusive.

It will be noted that heavy thinning has in every case tended to increase the percentage of large fruit. It is also apparent from Table 3 and Figure 2 that the proportion of culls differed little with distance of thinning. This result

TABLE 3.—INFLUENCE OF DEGREE OF THINNING ON SIZE OF APPLES.

Average yields in pounds per tree per year, 1930–35.

Thinning distance	Over 3 inches	2½ to 3 inches	2¼ to 2½ inches	Culls	Average yield per tree per year
in.	lb.	lb.	lb.	lb.	lb.
McIntosh—					
9	395	274	4	50	723±31·2
6	306	332	9	50	697±26·4
3	215	372	19	53	659±24·8
Delicious—					
9	284	346	32	60	722±26·7
6	265	377	40	56	738±35·8
3	121	408	80	46	655±49·4
Rome Beauty—					
9	172	301	29	39	541±12·5
6	100	311	58	38	507±41·7
3	95	286	60	39	480±36·6
Newtown—					
9	76	223	28	28	355±29·5
6	58	261	32	29	380±38·7
3	48	236	69	39	392±30·6



may be accounted for at least in part by the fact that windfalls were classed as culls. The apples on heavily thinned trees had a tendency to ripen earlier than those on trees receiving lighter thinning, with the result that there were more windfalls under the heavily thinned trees at the time of picking.

Influence of Degree of Thinning on Colour of Apples

At harvest time the fruit from each tree was graded to conform with the Dominion Government colour requirements for Extra Fancy, Fancy and C grades. The information secured by this procedure is presented in Table 4 and Figure 3. It will be noted that the percentage of Fancy grade apples remained

TABLE 4.—INFLUENCE OF DEGREE OF THINNING ON COLOUR OF APPLES.

Average yields in pounds, per tree per year, 1930–35.

Thinning distance	Extra Fancy	Fancy	C Grade	Culls	Total
in.	lb.	lb.	lb.	lb.	lb.
McIntosh—					
9	342	191	140	50	723±31·2
6	350	174	123	50	697±26·4
3	295	178	133	53	659±24·8
Delicious—					
9	416	143	103	60	722±26·7
6	442	119	121	56	738±35·8
3	271	151	187	46	655±49·4
Rome Beauty—					
9	103	158	241	39	541±12·5
6	72	140	257	38	507±41·7
3	61	130	250	39	480±36·6

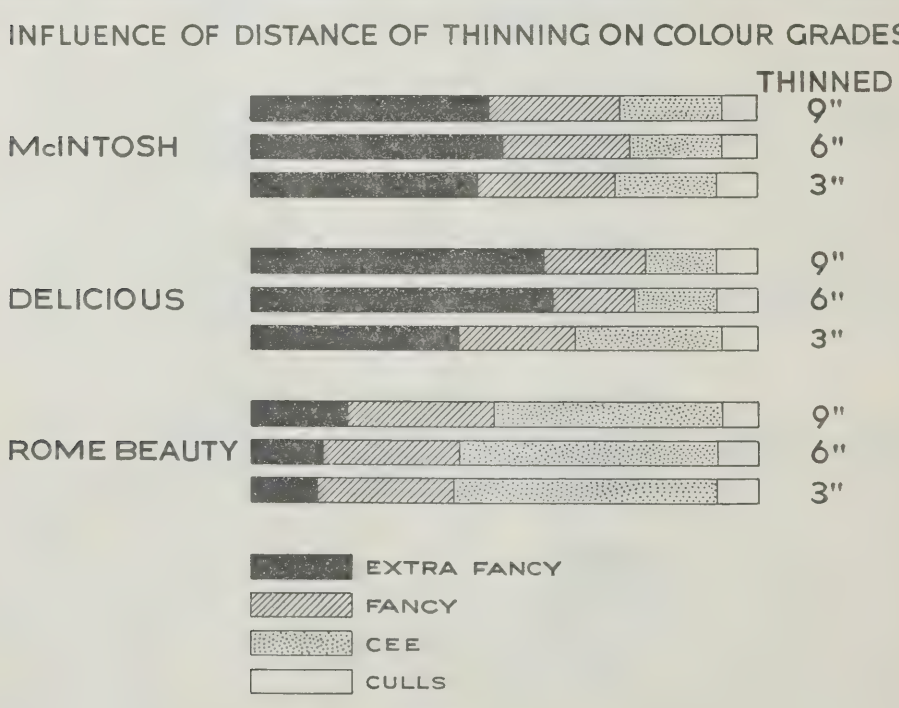


FIGURE 3

fairly constant for each variety regardless of the thinning treatments applied. In the case of Delicious, however, 9- and 6-inch thinning gave a markedly increased percentage of Extra Fancy fruit. On the other hand, McIntosh and Rome Beauty showed little influence of distance of thinning on colour development.

Influence of Degree of Thinning on Value of Apples

The value of any thinning treatment must be measured in terms of returns to the grower. In order to ascertain the value of fruit produced under the different thinning treatments, actual returns to the growers for the various sizes and colour grades were secured. These figures were kindly furnished by the Penticton Co-operative Growers Limited, and are presented in Table 5.

TABLE 5.—INFLUENCE OF SIZE AND GRADE ON RETURNS FOR APPLES.

Average prices paid to the grower per 40-pound box, 1931–1934.

Variety	Grade	Large	Medium	Small
		$ c.	$ c.	$ c
McIntosh	Extra Fancy			
	Fancy	0 39	0 42	0 42
	C	0 26	0 27	0 23
Delicious	Extra Fancy	0 51	0 81	0 78
	Fancy	0 62	0 67	0 63
	C	0 49	0 52	0 43
Rome Beauty	Extra Fancy			
	Fancy	0 48	0 48	0 43
	C	0 40	0 40	0 31
Newtown	Extra Fancy	0 76	0 80	0 80
	Fancy	0 64	0 67	0 68
	C	0 52	0 54	0 53

From the data presented in Table 5, together with the size and colour grading records and the figures for cost of thinning and harvesting, it has been possible to arrive at the net returns to the grower from the trees receiving each of the three thinning treatments. Cost of thinning has been calculated at 25 cents per hour for labour. This information is presented in Table 6.

TABLE 6.—INFLUENCE OF DEGREE OF THINNING ON RETURNS TO THE GROWER

Average costs and returns per tree per year, 1930–35.

Thinning distance	Gross returns	Cost of thinning	Cost of picking	Net returns
ins.	$ c.	$ c.	$ c.	$ c.
McIntosh—				
9	6 30	0 90	1 21	4 19
6	6 12	0 62	1 09	4 41
3	5 70	0 41	1 08	4 21
Delicious—				
9	10 02	0 75	0 85	8 42
6	10 21	0 53	0 95	8 73
3	9 29	0 28	0 80	8 21
Rome Beauty—				
9	5 49	0 76	0 56	4 17
6	5 01	0 57	0 54	3 90
3	4 67	0 42	0 55	3 70
Newtown—				
9	5 44	0 63	0 62	4 19
6	5 84	0 51	0 55	4 78
3	5 72	0 30	0 76	4 66

The figures presented in Table 6 indicate that cost of thinning ranged from about 35 cents a tree for light thinning and 55 cents a tree for medium thinning, to about 75 cents a tree for heavy thinning. This is equivalent to approximately 2½ cents a packed box (40 pounds) for light thinning, 4 cents for medium thinning, and 5 cents a box for heavy thinning. The costs of thinning were influenced somewhat by variety, averaging per tree about 48 cents for Newtown, 52 cents for Delicious, 58 cents for Rome Beauty and 64 cents for McIntosh. Taking into account the differences in variety yield, these figures are equivalent to a per box cost of approximately 3 cents for Delicious, 4 cents for McIntosh, 4½ cents for Rome Beauty and 5 cents for Newtown.

Costs of harvesting varied from about 55 cents per tree for Rome Beauty, to about $1.10 per tree for McIntosh, but were not greatly influenced by degree of thinning. Taking into account the differences in variety yields, the cost of picking per packed box was approximately 4½ cents for Rome Beauty, 5 cents for Delicious, 6½ cents for McIntosh, and 7 cents for Newtown.

With McIntosh, Delicious and Newtown, the net returns to the grower were slightly greater from 6-inch than from 9- or 3-inch thinning, whereas with Rome Beauty the greatest net returns were from 9-inch thinning. Having regard to the probable errors of the yields as shown in Tables 1 and 3, these differences in net returns are not significant.

Influence of Degree of Thinning on Bearing Habit of Apple Trees

In determining which were annual and which were biennial bearing trees, the past 16 years' crop records were examined for the trees included in the experiment. A tree which, after coming into commercial bearing, had produced regularly in the "off" year a crop equal to one-third or more of the crop in the preceding "on" year, was considered as an annual bearer. In one or two cases it was found that a tree with an annual bearing record had in some particular year failed to measure up to the annual bearing requirements. If, however, such a tree resumed in the following years its regular fruiting habit, it was still considered an annual bearer. Information secured from the above procedure is presented in Table 7.

TABLE 7.—INFLUENCE OF DEGREE OF THINNING ON BEARING HABIT OF APPLE TREES.

Variety	Thinning distance	No. of trees in each group	No. of annual bearers	Percentage of annual bearers
	ins.			%
McIntosh	9	6	5	83
	6	6	2	33
	3	6	3	50
Delicious	9	6	6	100
	6	6	6	100
	3	6	5	83
Rome Beauty	9	5	5	100
	6	5	5	100
	3	5	5	100
Newtown	9	6	2	33
	6	6	0	0
	3	6	0	0

The data presented in Table 7 illustrate the bearing habit of the four varieties and show the effect that various degrees of thininng have had on modifying the bearing habits of the trees under the conditions of this experiment. Rome Beauty has proven to be 100 per cent annual bearing, and Delicious almost 100 per cent annual bearing regardless of the thinning treatments applied.

Newtown and McIntosh, on the other hand, have shown distinct biennial bearing tendencies. It will be noted that with Newtown and McIntosh the percentage of annual bearers was greater with heavily thinned trees than it was with medium or lightly thinned trees. These results suggest that heavy thinning practised over a period of years has had a tendency to induce the annual bearing habit in McIntosh and Newtown under the conditions of this experiment.

Influence of Degree of Thinning on Apple Tree Growth

Using trunk cross sectional area as an index of tree growth, the effects of various degrees of thinning on size of tree are shown in Table 8.

TABLE 8.—INFLUENCE OF DEGREE OF THINNING ON TRUNK CROSS SECTIONAL AREA

Variety	Area of trunk cross section in square inches			Odds that 9-inch thinned trees have grown significantly larger than 3-inch thinned trees
	9 inch thinning	6 inch thinning	3 inch thinning	
	sq. in.	sq. in.	sq. in.	
McIntosh	188±6·49	160± 7·77	143±6·91	700 : 1
Delicious	147±5·9	135± 6·86	121±6·18	22 : 1
Rome Beauty	121±4·66	116±13·36	91±9·22	16 : 1
Newtown	114±4·51	114± 8·86	111±6·27	.....

From the data presented in Table 8 it is apparent that after 16 years of systematic thinning, heavily thinned trees of the McIntosh and Delicious varieties, are now significantly larger than lightly thinned trees. In the case of Rome Beauty and Newtown, however, the data are not significant.

Additional information regarding the influence of thinning treatment on tree size is presented in Table 9. The data presented show the influence of thinning treatment on the height and spread of apple trees. It will be noted that the height of the trees has not been materially influenced by thinning treatment. In this connection it may be well to point out that some heading back has been necessary to keep the trees low enough so that the fruit could be picked from a 16-foot ladder. The tree spread measurements likewise show only a very small and insignificant difference in growth between trees receiving various degrees of thinning.

TABLE 9.—INFLUENCE OF DEGREE OF THINNING ON HEIGHT AND SPREAD OF APPLE TREES

Variety	Thinning distance	Height	Spread East to West	Spread North to South
	in.	ft.	ft.	ft.
McIntosh	9	23·1	34·8	35·6
	6	23·1	33·7	35·5
	3	21·4	30·8	32·1
Delicious	9	21·5	30·7	32·0
	6	21·4	30·4	30·4
	3	19·1	28·1	28·1
Rome Beauty	9	20·8	25·9	26·4
	6	20·0	24·3	23·7
	3	19·2	24·0	23·1
Newtown	9	18·7	27·1	26·0
	6	19·2	26·0	25·4
	3	18·6	26·5	26·3

The data presented in Tables 8 and 9 suggest that heavy thinning has increased the diameter growth of the McIntosh, Delicious and Rome Beauty varieties, without materially increasing their height or spread.

TIME OF THINNING EXPERIMENTS

There is a great need for accurate experimental data concerning the economy of thinning apples at various stages of growth. It is most important that the grower know when thinning should be done to secure the greatest effect. He should also know when the operation can be performed with the least expenditure of time and effort. It was to provide the grower with such information that this project was undertaken.

MATERIALS AND METHODS

The trees used in time of thinning experiments were planted in 1916 and received good cultural treatment since that time, with the result that they were in a healthy, vigorous condition. Experiments were conducted on the Duchess of Oldenburg, Yellow Transparent, Wagener and Jonathan varieties as well as on McIntosh, Delicious, Rome Beauty and Yellow Newtown.

The procedure followed has been to select trees carrying a good crop and thin one main branch of each tree every two weeks, making the first thinning in the blossom stage and the last in August. This has resulted in eight separate dates of thinning for the different varieties, with the exception of Transparent and Duchess which were picked after the seventh thinning treatment. Heavy, medium and light thinning were practised, the apples being spaced approximately every 9, 6 and 3 inches of bearing wood, respectively. Ten apples on each branch were labelled with tinfoil tags. The apples were measured at thinning time and again when the fruit was harvested. At each thinning date careful observations were made concerning the ease with which the fruit could be removed. One or more branches on each tree were left unthinned for purposes of comparison.

PRESENTATION OF RESULTS

The results of time of thinning experiments conducted on the Summerland Experimental Station from time to time during the past 16 years are presented in the following pages, the influence of time of thinning being discussed under the headings: economy of operation, size, and colour.

Influence of Time of Thinning on Economy of Operation

The data presented in Table 10 show the sizes of apples thinned at different dates. At any given date it was found that the sizes of the unthinned fruits were practically identical regardless of whether they came from heavily, medium or lightly thinned trees. Accordingly, for the sake of conciseness, the average diameter of the fruits for each date of thinning from each group of three differently thinned trees is presented in Table 10.

TABLE 10.—INFLUENCE OF TIME OF THINNING ON DIAMETER OF APPLES AT THINNING TIME

Average of three years' results.

Variety	Diameter of fruit at thinning time							
	Time of thinning							
	1st	2nd	3rd	4th	5th	6th	7th	8th
	in.	in.	in.	in.	in.	in.	in.	in.
Transparent	Blossom stage	Calyx stage	0·87	1·36	1·76	1·98	2·14	.....
Duchess	"	"	1·15	1·61	1·94	2·17	2·41	.....
McIntosh	"	"	0·84	1·38	1·64	1·97	2·20	2·34
Delicious	"	"	0·62	1·16	1·50	1·79	2·05	2·30
Rome Beauty	"	"	0·74	1·25	1·58	1·75	2·03	2·22
Newtown	"	"	0·81	1·21	1·49	1·65	1·82	1·93
Wagener	"	"	1·04	1·45	1·72	1·99	2·20	2·40
Jonathan	"	"	0·67	1·05	1·34	1·61	1·81	1·94

The data presented in Table 10 are of special interest in connection with the observations on ease of thinning, and progress of the June drop. Thinning was more satisfactorily performed when the fruit was from 1 inch to 1½ inches in diameter. At that stage the apples could be rapidly removed with the fingers with a minimum of injury to the fruit and spur system of the tree. In many varieties, the fruits were quite difficult to remove until they had attained a diameter of an inch. Likewise apples 2 inches and over in size were found to be much harder to thin than those having a diameter of about 1½ inches. Newtown was found to be especially difficult to thin since the fruit of this variety sets in clusters and clings tenaciously to the spurs. A delay in thinning this variety until after the fruit reached a diameter of 1½ inches resulted in a considerable loss of time and breakage of spurs.

Thinning before the apples were 1 inch across involved a great deal of unnecessary labour as the June drop had not yet taken place. Furthermore, it was found that thinning in the blossom and calyx stages did not altogether prevent the June drop, with the result that, in some cases, too few apples were left to give a full crop. By the time the apples had attained a diameter of 1½ inches, the June drop was over.

Influence of Time of Thinning on Size of Apples

The influence of date of thinning on size of fruit at picking time is indicated by data presented in Table 11. It will be noted that there was, with most varieties, a definite tendency for the late thinned branches to produce fruit of comparatively small size. From a comparative study of these data it is apparent

TABLE 11.—INFLUENCE OF TIME OF THINNING ON DIAMETER OF APPLES AT HARVEST TIME.

Average of three years' results.

Variety	Thinning distance	Diameter of fruit at harvest time								
		Time of thinning								
		1st	2nd	3rd	4th	5th	6th	7th	8th	Unthinned
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Transparent	9	2·43	2·46	2·57	2·41	2·31	2·18	2·28	.....	2·07
	6	2·38	2·50	2·60	2·46	2·34	2·27	2·28	.....	2·23
	3	2·37	2·40	2·37	2·33	2·37	2·23	.....	.....	2·10
Duchess	9	2·84	2·84	2·79	2·69	2·62	2·53	2·48	.....	2·38
	6	2·65	2·77	2·68	2·64	2·60	2·55	2·47	.....	2·29
	3	2·76	2·73	2·70	2·68	2·64	2·45	2·45	.....	2·36
McIntosh	9	2·93	3·08	3·02	3·01	2·98	3·05	2·90	2·97	2·75
	6	2·57	2·70	2·83	2·87	2·66	2·80	2·74	2·71	2·75
	3	2·73	2·79	2·59	2·74	2·59	2·66	2·69	2·41	2·56
Delicious	9	2·68	2·91	2·99	2·93	2·80	2·98	2·83	2·84	2·79
	6	2·83	2·82	2·78	2·92	2·80	2·78	2·75	2·76	2·64
	3	2·87	2·81	2·84	2·80	2·67	2·75	2·74	2·84	2·84
Rome Beauty	9	3·17	3·17	3·13	3·07	2·95	2·91	2·91	2·91	2·73
	6	2·85	3·00	2·90	2·92	2·98	2·83	2·78	2·63	2·56
	3	2·90	2·75	2·99	2·79	2·86	2·76	2·78	2·70	2·51
Newtown	9	2·51	2·53	2·64	2·68	2·67	2·53	2·47	2·47	2·31
	6	2·70	2·73	2·68	2·67	2·61	2·62	2·57	2·45	2·41
	3	2·55	2·55	2·44	2·45	2·36	2·25	2·28	2·32	2·30
Wagener	9	3·08	3·06	3·08	3·17	3·13	2·99	2·95	2·84	2·77
	6	2·89	2·87	3·13	2·90	2·94	2·86	2·81	2·76	2·65
	3	2·70	2·72	2·75	2·73	2·86	2·72	2·79	2·69	2·67
Jonathan	9	2·84	2·78	2·82	2·82	2·76	2·68	2·70	2·64	2·52
	6	2·70	2·74	2·84	2·77	2·62	2·72	2·52	2·59	2·39
	3	2·59	2·63	2·65	2·66	2·60	2·63	2·60	2·52	2·40

that at harvest time there was relatively little difference in average size of the fruit of the varieties Duchess and Transparent thinned up to four weeks (third thinning) after blossoming time. At this date the diameter of the fruits was approximately 1 inch (Table 10). Similarly, with the varieties, Rome Beauty, Newtown, Wagener, and Jonathan, it appeared to be of little importance at what date the fruit was thinned, provided it was not later than 8 weeks (fifth thinning) after blooming time. At this date the fruit was between $1\frac{1}{2}$ and $1\frac{3}{4}$ inches in diameter. Jonathan had an average diameter of only 1·34 inches at this date. McIntosh and Delicious seemed to be virtually unaffected by the date at which thinning was carried out, producing as large fruit on the latest as on the earliest thinned branches. This is probably due in no small measure to the fact that McIntosh and Delicious had a larger leaf area per fruit than the other varieties included in the experiment. In all varieties, the average diameter of the apples on the unthinned branches was less than that of the thinned fruit.

It is also apparent from the data presented in Table 11 that at harvest time there were more pronounced and more consistent decreases in the sizes of the fruits between each thinning date in the heavily thinned than in the medium or lightly thinned trees. Figure 4 gives a graphical representation of the relationship between diameter of fruit at thinning and diameter at picking for

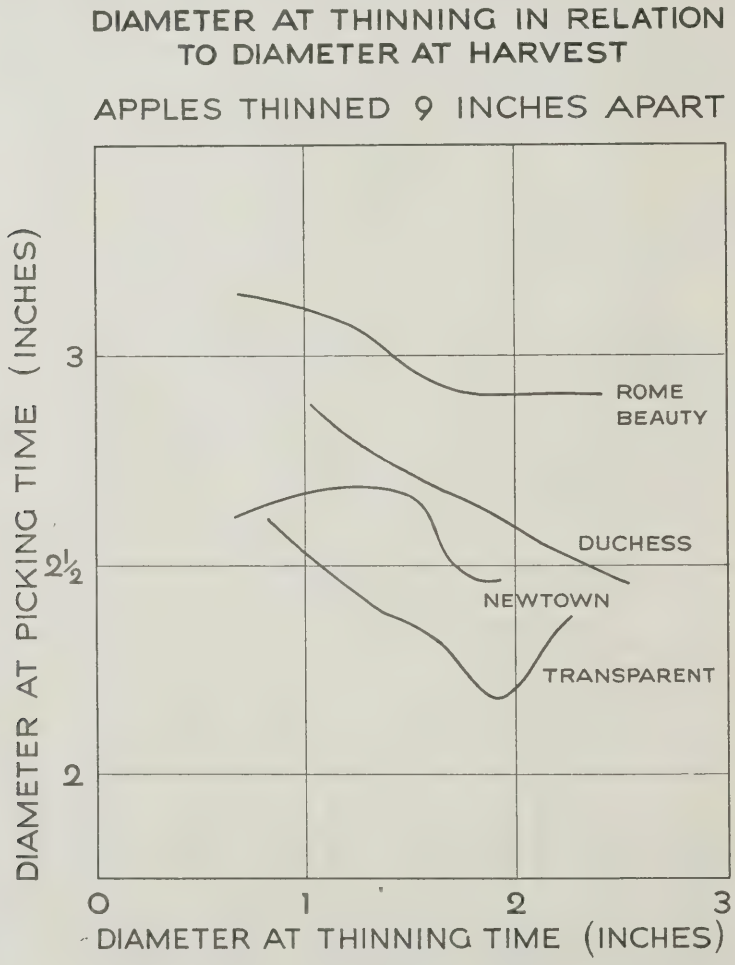


FIGURE 4

the 9-inch thinned trees of the varieties Rome Beauty, Duchess, Newtown, and Transparent. It is evident that for the varieties Rome Beauty, Transparent and Duchess, increasing lateness of thinning had a consistent effect in reducing size of fruit at harvest.

Since the results obtained in the above experiment seemed to show such small differences in the size of mature fruits from branches thinned at different dates, it was decided to conduct another experiment in dates of thinning, this time comparing whole trees instead of single limbs. It was planned to contrast the results from three dates of thinning, June 15, July 15, and August 15, employing a heavily, medium, and lightly thinned tree on each date.

Accordingly, nine 17-year-old trees of each of the varieties Wagener and Delicious were selected, care being taken to choose trees which were relatively uniform in size and vigour, and in their heavy bearing year. At each date of thinning, and also at harvest time, the diameters were measured of 100 apples distributed well throughout the bearing surface of the tree. The average diameters obtained from each of these determinations are presented in Table 12. The figures represent averages for two years with Delicious, and one year with Wagener. These averages indicate that the trees employed in this experiment carried remarkably uniform crops, since at each date of thinning the 9-, 6- and 3-inch thinned trees all bore fruit almost identical in diameter.

TABLE 12.—INFLUENCE OF DATE OF THINNING ON DIAMETER OF FRUIT AT HARVEST TIME

Average for two years on Delicious, one year on Wagener.

Variety	Thinning date	Thinning distance	Diameter of apples at thinning	Diameter of apples at harvest
		in.	in.	in.
Delicious	June 13	9	0·70	2·86
		6	0·72	2·64
		3	0·75	2·60
	July 13	9	1·64	2·79
		6	1·57	2·74
		3	1·60	2·72
	Aug. 13	9	2·23	2·91
		6	2·15	2·78
		3	2·18	2·71
Wagener	June 13	9	0·98	3·11
		6	0·96	2·85
		3	0·97	2·70
	July 13	9	1·68	2·85
		6	1·68	2·90
		3	1·70	2·83
	Aug. 13	9	2·02	2·74
		6	2·07	2·78
		3	2·03	2·70

The average diameters of the apples at harvest time as shown in Table 12, indicate that with Delicious there was no significant difference in size of the fruits when picked, regardless of the dates at which the thinning was done. With Wagener, on the other hand, there is evidence that thinning in August resulted in smaller fruit than was secured from trees which were thinned in June or July.

With both varieties late thinning resulted in removal of large quantities of food materials which would presumably have been retained in the trees had the thinning operation been performed earlier in the growing season. These food materials might be expected to exert some effect on the growth of the trees and on subsequent fruit bud formation.

At harvest, the apples from each tree were graded for size and colour. The fruit was divided into four size grades; viz., large, medium, small, and culls; with diameters of over 3 inches, $2\frac{1}{2}$ to 3 inches, $2\frac{1}{4}$ to $2\frac{1}{2}$ inches, and under $2\frac{1}{4}$ inches respectively. Windfalls and fruits affected by limb-rub or other deformity were classified as culls. The colour grades were designated Extra Fancy, Fancy, and C grade, and conformed to Dominion Government standards for each variety. The results secured are shown in Tables 13 and 14.

The data presented in Table 13 provide additional evidence that date of thinning had no significant effect on yield or size of fruit harvested from Delicious, but that late thinning resulted in reduced size and reduced yield of Wagener.

These apparently inconsistent results may quite possibly be due to differences in leaf area per foot of bearing wood on the two varieties.

TABLE 13.—INFLUENCE OF DATE OF THINNING ON YIELD AND SIZE OF APPLES.

Averages for two years on Delicious, one year on Wagener.

Thinning date	Thinning distance	Total yield	Large	Medium	Small	Culls
	in.	lb.	%	%	%	%
Delicious—						
June 13	9	997	41	50	3	6
	6	1,010	20	68	6	6
	3	929	23	57	12	8
Average			28	58	7	7
July 13	9	922	27	65	3	5
	6	888	26	64	5	5
	3	965	8	69	18	5
Average			20	66	9	5
Aug. 13	9	655	43	49	2	6
	6	892	24	67	4	5
	3	712	11	77	6	6
Average			26	64	4	6
Wagener—						
June 13	9	480	73	24	1	2
	6	490	34	57	6	3
	3	765		69	20	11
Average			36	50	9	5
July 13	9	570	29	60	3	8
	6	495	31	61	2	6
	3	545	20	70	5	5
Average			27	64	3	6
Aug. 13	9	415	10	80	7	3
	6	260	6	86	6	2
	3	440		80	16	4
Average			5	82	10	3

Influence of Time of Thinning on Colour of Apples

It was also desired to ascertain whether time of thinning exerted any important influence on colour of apples. Data bearing on this point are presented in Table 14. In the case of Delicious the average figures suggest that the later the trees were thinned, the greater was the percentage of Extra Fancy fruit secured, but the differences are small and not significant. It might be pointed out, however, that the average colour of the apples on the late thinned Delicious may have been raised by the fact that only the highest coloured fruits were

permitted to remain on the trees, the poorly coloured specimens being thinned off. Wagener, on the other hand, showed practically no effect of time of thinning on colour, producing virtually the same percentages of all grades of fruit from the trees thinned on each of the three dates.

TABLE 14.—INFLUENCE OF DATE OF THINNING ON COLOUR OF APPLES.

Averages for two years on Delicious, one year on Wagener.

Thinning date	Thinning distance	Total yield	Percentage fruit of each colour grade			
			Extra Fancy	Fancy	C Grade	Culls
	in.	lb.	%	%	%	%
Delicious—						
June 13	9	997	81	7	6	6
	6	1,010	62	18	14	6
	3	929	43	17	33	7
Average			62	14	18	6
July 13	9	922	77	10	8	5
	6	888	64	11	20	5
	3	965	73	14	8	5
Average			71	12	12	5
Aug. 13	9	655	75	12	7	6
	6	892	79	11	5	5
	3	712	69	13	12	6
Average			74	12	8	6
Wagener—						
June 13	9	480	51	21	26	2
	6	490	43	23	31	3
	3	765	17	40	31	12
Average			37	28	29	6
July 13	9	570	42	27	23	8
	6	495	38	31	25	6
	3	545	20	31	44	5
Average			33	30	31	6
Aug. 13	9	415	40	30	26	4
	6	260	37	31	30	2
	3	440	32	27	36	5
Average			36	29	31	4

DISCUSSION OF RESULTS

The results of experiments reported in this bulletin suggest that leaf area is of paramount importance in determining fruit size; and that thinning provides a means of apportioning the crop to the leaf area in such a way as to secure fruit of the desired sizes. Thus the degree of thinning which should be practised with any particular variety or tree of a variety depends on the leaf area carried by the tree and the size of fruit required. With healthy McIntosh trees which commonly carry a large leaf area per foot of branch, 3-inch spacing may be quite sufficient to secure fruit of popular market sizes. On the other hand, with varieties such as Winesap, characterized by a comparatively small leaf area per foot of branch, thinning to as much as 9 inches apart may be desirable.

Early apples such as Yellow Transparent and Duchess can be thinned to good advantage about a month after the blossom period. At this time the fruit is usually about 1 inch in diameter, the thinnings can be easily removed and the

maximum effect on the size of the remaining fruit is secured. Early thinning is also advisable with the Newtown as the short stems characteristic of this variety make the fruits difficult to remove after they have reached a diameter of 1½ inches.

The heavy June drop commonly experienced with the McIntosh and Delicious makes very early thinning of these varieties inadvisable. Furthermore, the influence of time of thinning on size and colour of these varieties appears to be very small. However, there is some evidence that while late thinning may give as good results as earlier thinning in any particular year, such a practice if continued over a period of years would tend to devitalize the trees to an unnecessary extent. Early removal of superfluous fruits can be expected to reduce the requirements for food materials needed to develop the crop, leaving more for wood growth and the building up of reserves in the tree. Add to this the fact that the fruits can be most readily removed when they are between 1 and 1½ inches in diameter, and there seems good reason to complete the thinning operation with all varieties before the fruits reach a diameter of 2 inches.

SUMMARY

Literature on thinning of apples is reviewed. A degree of thinning experiment involving spacing of the fruits approximately 9, 6 and 3 inches apart is described. This experiment has been in progress with 72 trees over a period of 16 years. Time of thinning experiments which have been conducted with smaller numbers of trees over shorter periods of time are also outlined. The crop from each tree has been graded for both size and colour, and the net returns to the grower determined. Information has also been secured regarding the influence of thinning on the growth and bearing habit of the trees.

The results recorded may be briefly summarized as follows:

1. The trees included in the degree of thinning experiment produced substantially the same total amount of fruit over the 16-year period regardless of the degree of thinning practised.

2. Heavy thinning resulted in an increased set of fruit.

3. Fruit from heavily thinned trees averaged larger than fruit from medium thinned trees, and fruit from medium thinned trees averaged larger than fruit from lightly thinned trees.

4. The influence of degree of thinning on development of red colour was small and inconsistent.

5. The cost of heavy, medium and light thinning amounted to approximately 5 cents a packed box (40 pounds) for heavy thinning, 4 cents a box for medium thinning, and 2½ cents a box for light thinning.

6. The cost of picking the crop from heavy, medium and light thinned trees of each variety was not greatly influenced by degree of thinning, amounting to approximately 4½ cents a box for Rome Beauty, 5 cents for Delicious, 6½ cents for McIntosh, and 7 cents for Newtown.

7. The influence of degree of thinning on net returns to the grower was small and inconsistent.

8. Most of the Delicious and Rome Beauty trees bore annual crops regardless of the degree of thinning practised. On the other hand, with the McIntosh and Newtown varieties, more of the light and medium thinned trees developed the biennial bearing habit than was the case with heavily thinned trees.

9. Heavy thinning resulted in increased trunk cross sectional area of the McIntosh and Delicious varieties without materially increasing their height or spread.

10. Thinning was most easily accomplished when the fruits were from 1 inch to 1½ inches in diameter.

11. Time of thinning had a significant influence on size of fruit at harvest with the Transparent, Duchess, Rome Beauty, Newtown and Wagener varieties, but with McIntosh and Delicious differences in size of fruit due to date of thinning were not significant.

12. The influence of date of thinning on colour was small and inconsistent.

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